CHAPTER I - OPERATIONAL PROCEDURES

1. GENERAL

The Joint Typhoon Warning Center (JTWC) provides a variety of routine services to the organizations within its area of responsibility, including:

a. SIGNIFICANT TROPICAL WEATHER ADVISORIES

Issued daily, these products describe all tropical disturbances and assess their potential for further development during the advisory period.

b. TROPICAL CYCLONE FORMATION ALERTS

Issued when synoptic or satellite data indicate development of a significant tropical cyclone, in a specified area, is likely.

c. TROPICAL CYCLONE WARNINGS

Issued periodically throughout each day, for significant tropical cyclones, giving forecasts of position and intensity of the system.

d. PROGNOSTIC REASONING MESSAGES

Issued with each warning for tropical depressions, tropical storms, typhoons and super typhoons in the western North Pacific; these messages discuss the rationale behind the most recent JTWC warnings.

JTWC's customers determine the content of JTWC's products according to their changing requirements. Therefore, the spectrum of routine services is subject to change from year to year. Such changes are usually the result of deliberations held at the Annual Tropical Cyclone Conference.

2. DATA SOURCES

a. COMPUTER PRODUCTS

A standard array of numerical and statistical guidance are available from the USN Fleet Numerical Oceanography Center (FNOC) at Monterey, California. FNOC products are received through the Naval Environmental Data Network (NEDN), the Naval Environmental Satellite Network (NESN) and by micro-computers connected to mainframe computers via military and commercial telephone lines.

b. CONVENTIONAL DATA

This data set is comprised of land-based, ship surface and upper-air observations recorded at, or within six hours of, synoptic times. It incorporates cloud-motion winds derived twice a day from satellite imagery and commercial and military Aircraft Reports (AIREPS) of enroute meteorological observations, within six hours of synoptic times. There has been an effort to increase the frequency and use of AIREPS to describe the synoptic situation in otherwise data sparse regions. Additional conventional data sources include three Automated Meteorological Observing Station (AMOS) sites on the islands of Saipan and Rota in the Mariana Islands, and Faraulep in the Caroline Islands. The conventional data is hand plotted and analyzed in the tropics for the surface/gradient and 200 mb levels. These analyses are prepared twice daily from 0000Z and 1200Z synoptic data. Also, FNOC supplies JTWC with computer streamline analyses and prognoses at the 925 mb, 850 mb, 700 mb, 500 mb, 400 mb, 250 mb and 200 mb levels from 0000Z and 1200Z synoptic data.

c. AIRCRAFT RECONNAISSANCE

Aircraft of opportunity are a valuable for providing meteorological data at flight level around the periphery of tropical cyclones and in describing the environment away from tropical cyclones that frequently affect tropical cyclone motion. With their airborne radar, they can remotely sense the inner rainbands and core of the tropical cyclone. Flight safety considerations preclude the use of transient aircraft for tropical cyclone penetration.

d. SATELLITE RECONNAISSANCE

Meteorological satellite imagery recorded at USAF/USN ground sites and USN ships supply day and night coverage in JTWC's area of responsibility. Interpretation of these satellite data provide tropical cyclone positions and estimates of current and forecast intensities (Dvorak, 1984).

e. RADAR RECONNAISSANCE

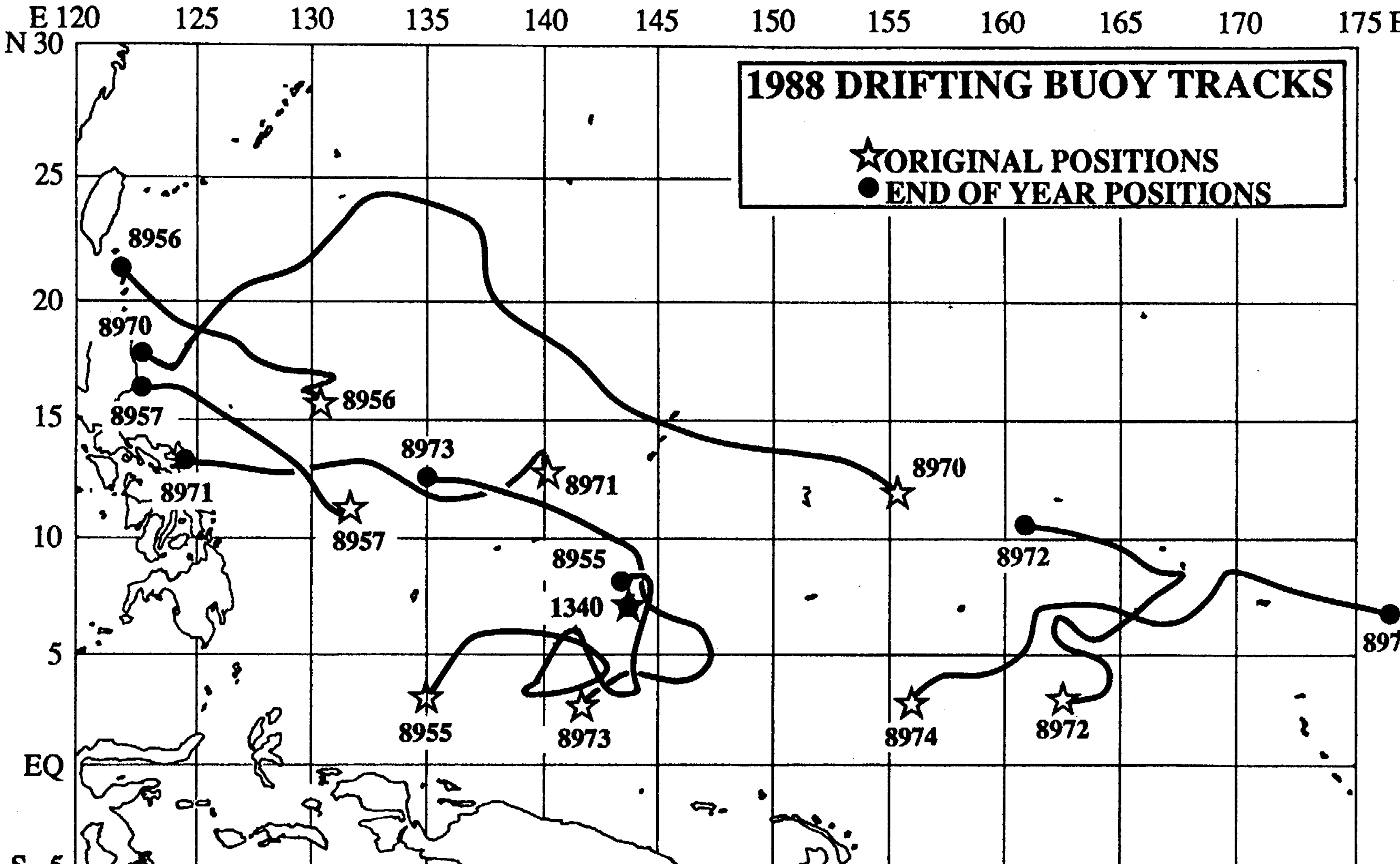
During 1988, as in previous years, land-based radar coverage was utilized extensively, when available. Once a tropical cyclone moved within the range of land-based radar sites, their reports were essential for determination of small-scale movement. Use of radar reports during 1988 is discussed in Chapter II.

f. DRIFTING METEOROLOGICAL BUOYS

In July 1988, nine drifting meteorological buoys were deployed in the western North Pacific to increase the availability of synoptic data, in an often data sparse region. The Naval Oceanography Command provided the funds for procurement and deployment of the buoys and data acquisition equipment. The Naval Oceanographic Office, and JTWC, planned and coordinated the buoy deployments. The 21st Tactical Airlift Squadron at Clark Air Base in the Republic of the Philippines deployed the buoys from C-130 aircraft. All of the buoys provided sea-level pressure, air and sea surface temperatures. Six of the Tropical Ocean Global Atmosphere (TOGA) buoys were retrofitted to provide wind speed and direction. Five buoys were deployed at seven-degree longitude intervals along three degrees North latitude, just south of the Caroline Islands. One of these buoys failed to activate on deployment. (Ironically, a buoy from the 1987 deployment remained active, trapped in an atoll near the failed buoy.) Three buoys were deployed in the Philippine Sea, and the remaining buoy was deployed east of Guam.

JTWC acquired the drifting buoy data directly through its Local User Terminal (LUT). The buoys transmit data to the Tiros-N polar orbiting satellites, which in turn store and relay the data to JTWC's LUT. Four to six observations per day are available from each buoy via direct readout. The stored data is dumped to Service ARGOS in Washington, D.C., where it is passed to the National Data Buoy Center (NDBC) for quality control. JTWC receives the data from NDBC via the Automated Weather Network (AWN). The buoys' positioning systems, wind speed, air pressure and temperature sensors provided accurate data. However, the wind direction data on the modified TOGA's were unreliable. JTWC's internal quality control program computed coarse corrections in an attempt to salvage wind directions, but the results were only of marginal use for the manual surface/gradient level streamline analyses.

The buoys furnished data on Super Typhoon Nelson (20W), Typhoons Odessa (21W), Pat (22W) , Ruby (23W), Skip (24W), Tess (25W), and Tropical Storms Lee (18W) and Val (26W). The tracks of the drifting buoys can be seen in Figure 1-1. Three buoys ceased operating after washing ashore in the Philippine Islands during October, November and December. By the end of 1988, five of nine buoys from the 1988 deployment and one buoy from the 1987 deployment remained operational.


1988 DRIFTING BUOY TRACKS
ORIGINAL POSITIONS
END OF YEAR POSITIONS
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3. COMMUNICATIONS

a. AUTOMATED DIGITAL NETWORK (AUTODIN)

AUTODIN is used for dissemination of warnings, alerts and other related bulletins to Department of Defense installations. These messages are relayed for further transmission over Navy Fleet Broadcasts, and Coast Guard CW (continuous wave Morse Code) and voice broadcasts. Inbound message traffic for JTWC is received via AUTODIN addressed to NAVOCEANCOMCEN GQ or DET 1, 1WW NIMITZ HILL GQ.

b. AUTOMATED WEATHER NETWORK (AWN)

The AWN provides weather data over the Pacific Meteorological Data System (PACMEDS). Operational for JTWC in April 1988, the PACMEDS allows Pacific-Theater agencies to receive weather information at 1200 baud, which is an upgrade from the older 75 baud teletype systems, eliminating data backlogs. The system provides the large volume of meteorological reports necessary to satisfy JTWC requirements. Weather bulletins prepared by JTWC are inserted into the AWN circuit through the Nimitz Hill Naval Telecommunications Center (NTCC), which is controlled by the Naval Communications Area Master Station (NAVCAMS) Western Pacific located on Guam.

c. AUTOMATIC VOICE NETWORK (AUTOVON)

AUTOVON is a world-wide general purpose switched voice network for the Department of Defense. The network provides a rapid and vital voice link for JTWC to communicate tropical cyclone information to customers. The AUTOVON telephone number for JTWC is 344-4224.

d. NAVAL ENVIRONMENTAL DATA NETWORK (NEDN)

The NEDN continues to provide processed and raw environmental data from FNOC to JTWC, and is a communication line for requesting and receiving forecast aids via FNOC's mainframe computers.

e. TIME-SHARING NETWORK (TYMNET)

The use of TYMNET through the Automated Tropical Cyclone Forecast (ATCF) system started in 1987 and aided JTWC's shift away from exclusive dependence on the Naval Environmental Display Station (NEDS) for processing and transmission of tropical cyclone forecast aids, and for receiving environmental fields and raw data. The use of the ATCF microcomputers has improved both the speed of handling and the quality control of these data.

f. DEFENSE DATA NETWORK (DDN)

The DDN is a Department of Defense network of communication lines/links to exchange data files. Because the DDN has links, or gateways, to non-military information networks, it has demonstrated an excellent potential for interfacing with the research community. It was used routinely to transmit SSM/I data from AFGWC to JTWC.

g. TELEPHONE FACSIMILE (TELEFAX)

TELEFAX provides the capability to rapidly scan and transmit, or receive, documents over commercial telephone lines or AUTOVON. The TELEFAX is used to disseminate tropical cyclone advisories and warnings to key agencies on Guam and in special situations the other Micronesian Islands. Inbound documents for JTWC are received via commercial telephone at (671) 477-6186. If inbound through AUTOVON, the Guam AUTOVON operator 322-1110 can transfer the call to the commercial number 477-6186.

h. NAVAL ENVIRONMENTAL SATELLITE NETWORK (NESN)

The NESN's primary function is to pass satellite data between FNOC and regional centers. It can provide a limited back-up for the NEDN.

4. DATA DISPLAYS

a. NAVAL ENVIRONMENTAL DISPLAY STATION (NEDS)

The NEDS is the mainstay for producing displays and hard copies of FNOC environmental products. However, it now serves as a backup for the transmission and receipt of FNOC's objective forecast aids and JTWC's weather messages.

b. AUTOMATED TROPICAL CYCLONE FORECAST SYSTEM (ATCF)

Increased usage of microcomputers in the ATCF has shortened the processing time and improved the quality control of weather bulletins; especially the warnings. The ATCF is still a step away from direct interface with NTCC for AWN and AUTODIN message transmissions, but the Joint Typhoon Warning Center Automation Project (JTWC-AP) will make this needed interface a reality.

c. PACIFIC DIGITAL INFORMATION GRAPHICS SYSTEM (PACDIGS)

The PACDIGS is a new communications circuit that was expanded to include JTWC in 1988. Air Force Global Weather Central (AFGWC) at Omaha, Nebraska provides a standard set of numerical products to the PACDIGS circuit.

d. NAVAL SATELLITE DISPLAY SYSTEM (NSDS)

The NSDS functions primarily for display of FNOC stored satellite imagery and can provide limited back up for the NEDN, via the NESN.

5. ANALYSES

A composite surface/gradient-level (3000 ft (914 m)) manual analysis of the JTWC area of responsibility is accomplished daily on the 0000Z and 1200Z conventional data. Analysis of the wind field using streamlines is stressed for tropical and subtropical regions. Analysis of the pressure field outside the tropics is accomplished routinely by the Naval Oceanography Command Center Operations watch team and is used by JTWC in conjunction with their analysis of the tropical wind fields.

A composite upper-tropospheric manual streamline analysis is accomplished daily at 0000Z and 1200Z, utilizing rawinsonde data from 300 mb through 100 mb, winds obtained from satellite-derived cloud motion analysis, and AIREPS (taken plus or minus three hours of chart valid time) at or above 31,000 ft (9,449 m). Wind and height data are used to generate a representative analysis of tropical cyclone outflow patterns, mid-latitude steering currents, and features that may influence tropical cyclone intensity. All charts are hand-plotted in the tropics to provide all available data as soon as possible to the Typhoon Duty Officer (TDO). These charts are augmented by computer-plotted charts for the final analysis.

Computer analyses for the 925, 850, 700, 500, 400, 250 and 200 mb levels are available from the 0000Z and 1200Z data base. Additional sectional charts at intermediate synoptic times and auxiliary charts, such as station-time plot diagrams and pressure-change charts, are also analyzed during periods of significant tropical cyclone activity.

A Hovmöller Trough-and-Ridge Diagram for 500 mb at 40° North and 30° South latitudes for the entire hemisphere is produced daily to provide a quick look at trough and ridge progression with time.

6. FORECAST AIDS

The following objective tropical cyclone forecasting techniques were employed during 1988 (a description of each technique is presented in Chapter V):

a. MOVEMENT

(1) EXTRAPOLATION

(2) CLIMATOLOGY

(3) HPAC (Half Persistence - Half Climatology Blend)

(4) CLIPER (Climatology and Persistence Technique)

(5) COSMOS (Model Output Statistics)

(6) CSUM (Statistical Dynamic Model)

(7) OTCM (Dynamic Model)

(8) TAPT (Empirical)

(9) TYAN78 (Analog)

b. INTENSITY

(1) CLIMATOLOGY

(2) DVORAK (Empirical)

(3) HOLLAND/MARTIN (Empirical)

7. FORECAST PROCEDURES

a. INITIAL POSITIONING

The warning position is the best estimate of the center of the surface circulation at synoptic time. It is estimated from an analysis of all fix information received up to one and one-half hours after synoptic time. This analysis is based on a semi-objective weighting of fix information based on the historical accuracy of the fix platform and the meteorological features used for the fix. The interpolated warning position reduces the weighting of any single fix and results in a more consistent movement and a warning position that is more representative of the larger-scale circulation. If the fix data are not available due to reconnaissance platform malfunction or communication problems, synoptic data or extrapolation from previous fixes are used.

b. TRACK FORECASTING

A preliminary forecast track is developed based on an evaluation of the rationale behind the previous warning and the guidance given by the most recent set of objective techniques and numerical prognoses. This preliminary track is then subjectively modified based on the following considerations:

(1) The prospects for recurvature or erratic movement are evaluated. This determination is based primarily on the present and forecast positions and amplitudes of the middle-tropospheric, mid-latitude troughs and ridges as depicted on the latest upper-air analysis and numerical forecasts.

(2) Determination of the best steering level is partly influenced by the maturity and vertical extent of the tropical cyclone. For mature tropical cyclones located south of the subtropical ridge axis, forecast changes in speed of movement are closely correlated with anticipated changes in the intensity or relative position of the ridge. When steering currents are relatively weak, the tendency for tropical

cyclones to move northward due to internal forces is an important consideration.

(3) Over the 12- to 72-hour (12- to 48-hour in the southern hemisphere) forecast period, speed of movement during the early forecast period is usually biased towards persistence, while the later forecast periods are biased towards objective techniques. When a tropical cyclone moves poleward, and toward the mid-latitude steering currents, speed of movement becomes increasingly more biased toward a selective group of objective techniques capable of estimating acceleration.

(4) The proximity of the tropical cyclone to other tropical cyclones is closely evaluated to determine if there is a possibility of interaction.

A final check is made against climatology to determine whether the forecast track is reasonable. If the forecast deviates greatly from one of the climatological tracks, the forecast rationale will be reappraised.

c. INTENSITY FORECASTING

Heavy reliance is placed on the empirically derived Dvorak (1984) model for forecasting tropical cyclone intensity. Other techniques used for forecasting intensity are extrapolation of synoptic wind and pressure data and climatology. An evaluation of the entire synoptic situation is made, including the location of major troughs and ridges, the position and intensity of any nearby Tropical Upper-Tropospheric Troughs (TUTTs), the vertical and horizontal extent of the tropical cyclone's circulation and the extent of the associated upper-level outflow pattern. Each intensity forecast is affected by the accompanying forecast track and environmental influences along that track; such as, terrain, vertical wind shear and extratropical weather features.

d. WIND-RADII FORECASTING

A new wind profile and steering diagnostic is being used at JTWC. The technique is the result of efforts by Dr. G. J. Holland (Office of Naval Research contractor) and Maj. J. Martin. The technique adapts an earlier work (Holland, 1980) and specifically addresses the need for realistic 30-, 50- and 100-kt wind radii around tropical cyclones. It solves equations for basic gradient wind relations within the tropical cyclone area, using input parameters obtained from enhanced infrared satellite imagery. For the first time, diagnoses also include asymmetric areas of winds caused by tropical cyclone movement. Size and intensity parameters are also used to diagnose internal steering components of tropical cyclone motion known collectively as "Beta-drift". The Holland/Martin wind radii technique replaces the more general Huntley (1980) technique.

8. WARNINGS

Tropical cyclone warnings are issued when a closed circulation is evident and maximum sustained winds are forecast to increase to 34 kt (18 m/sec) within 48-hours, or if the tropical cyclone is in such a position that life or property may be endangered within 72-hours. Warnings may also be issued in other situations if it is determined that there is a need to alert military or civil interests to threatening tropical weather conditions.

Each tropical cyclone warning is numbered sequentially and includes the following information: the position of the surface center; estimate of the position accuracy and the supporting reconnaissance (fix) platforms; the direction and speed of movement during the past six hours (past 12-hours in the southern hemisphere); the intensity and radial extent of over 30-, 50-, and 100-knot surface winds, when applicable. At forecast intervals of 12-, 24-, 48-, and 72-hours (12-, 24-, and 48-hours in the southern hemisphere), information on the tropical cyclone's anticipated position, intensity and wind radii are also provided. Vectors indicating the mean direction and mean speed between forecast positions are also included in all warnings.

Warnings in the western North Pacific and North Indian Oceans are issued every six hours valid at standard times: 0000Z, 0600Z, 1200Z and 1800Z (every 12-hours: 0000Z, 1200Z or 0600Z, 1800Z in the southern hemisphere). All warnings are released to the communications network no earlier than synoptic time and no later than synoptic time plus two and one-half hours, so that recipients will have a reasonable expectation of having all warnings "in hand" by synoptic time plus three hours (0300Z, 0900Z, 1500Z and 2100Z).

Warning forecast positions are later verified against the corresponding "best track" positions (obtained during detailed post-storm analyses to determine the most probable path and intensity of the cyclone). A summary of the verification results for 1988 is presented in Chapter V.

9. PROGNOSTIC REASONING MESSAGES

This plain language message is intended to provide meteorologists with the reasoning behind the latest forecast. For tropical depressions, tropical storms, typhoons and super typhoons in the western North Pacific Ocean, prognostic reasoning messages are transmitted following each warning. This is a change from 1987, when prognostic reasoning messages for western North Pacific tropical storms, typhoons and super typhoons were transmitted after the 0000Z and 1200Z warnings, or whenever the previous forecast reasoning was no longer valid.

In addition to this message, prognostic reasoning information, applicable to all customers, is provided in the remarks section of warnings when significant forecast changes are made or when deemed appropriate by the TDO.

10. TROPICAL CYCLONE FORMATION ALERTS

Tropical Cyclone Formation Alerts (TCFAs) are issued whenever interpretation of satellite imagery and other meteorological data indicate that the formation of a significant tropical cyclone is likely. These Alerts will specify a valid period not to exceed twenty-four hours and must either be cancelled, reissued, or superseded by a tropical cyclone warning prior to the expiration of the valid time.

11. SIGNIFICANT TROPICAL WEATHER ADVISORIES

This product contains a general, non-technical description of all tropical disturbances in JTWC's area of responsibility (AOR) and an assessment of their potential for further (tropical cyclone) development. In addition, all tropical cyclones in warning status are briefly discussed. Two separate messages are issued daily and are valid for a 24-hour period. The Significant Tropical Weather Advisory for the western Pacific Ocean (ABPW PGTW) covers the area east of 100° East longitude to the dateline and is issued by 0600Z. The Significant Tropical Weather Advisory for the Indian Ocean (ABIO PGTW) covers the area west of 100° East longitude to the coast of Africa and is issued by 1800Z. These are reissued whenever the situation warrants. For each suspect area, the words "poor", "fair", or "good" are used to describe the potential for development. "Poor" will be used to describe a tropical disturbance in which meteorological conditions are currently unfavorable for development; "fair" will be used to describe a tropical disturbance in which the meteorological conditions are favorable for development but significant development has not commenced; and "good" will be used to describe the potential for development of a tropical disturbance covered by a Tropical Cyclone Formation Alert.